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CONTENTS

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WILLIAM HENRY WELCH[1]

A BIOGRAPHICAL SKETCH

ON this memorable and beautiful occasion I have the cherished honor of having been chosen to perform, as it were, the duties of chronicler, in order that we may all be led to review in our minds the successive steps by which our great leader and master rose to such high distinction and wrought the miracle of giving to medicine a new birth in this country; and in order, also, that our successors, lighting their lamps at the shrine of Pathology and studying the treasures which these precious volumes enclose, may catch a gleam of what manner of man he was who produced them, and by the vigor of his living example and the charm of a rare personality, as well as by the power of his spoken and written word, in the short span of a lifetime raised medicine in the United States from a beneficent art to an expanding science.

William Henry Welch was born in Norfolk, Connecticut, April 8, 1850. He was the son of William and Emeline (Collin) Welch. His father was a practising physician, as were four of his father's brothers. Moreover, a great grandfather and grandfather were also physicians. When about one year of age, William Henry's mother died; thereafter he was

[1] An introduction to the collected papers and addresses of Dr. Welch, compiled in his honor on the occasion of his seventieth birthday, to be published in three volumes by the Johns Hopkins Press under the editorial supervision of a committee consisting of John J. Abel, Lewellys F. Barker, Frank Billings, Walter C. Burket, William T. Councilman, Harvey Cushing, John M. T. Finney, Simon Flexner, William S. Halsted, William H. Howell, John Howland, Henry M. Hurd, Henry Barton Jacobs, William W. Keen, Howard A. Kelly, William G. MacCallum, William J. Mayo, Ralph B. Seem, Winford H. Smith, William S. Thayer, J. Whitridge Williams, Hugh H. Young.

taken care of and brought up by his paternal grandmother, who resided with the father. A contemporary describes the youth as a great favorite in the village, interested in all kinds of sports and athletic exercises. During the Civil War, the youthful William became captain of a company of zouaves, who, dressed in regulation costume and provided with guns, drilled regularly on the village green. When about twelve years old, William was sent to a nearby boarding school at Winchester Centre, conducted by the Reverend Ira W. Pettibone, an uncle by marriage. Here he prepared for Yale College which he entered in 1866, in his sixteenth year, and from which he was graduated in 1870, with the A.B. degree, standing third in his class. During his college period he impressed his teachers and classmates with the possession of the gifts which afterwards distinguished him in so large a measure. After graduation and before entering upon his medical studies, Welch taught school for one year at Norwich, New York.

Thus it was in his twenty-first year that Welch matriculated at the College of Physicians and Surgeons, in New York City. But this first venture into medicine was very brief. An almost prophetic vision into the future gave him pause and led to his return to New Haven for a year of study in chemistry, which field even at that early date he perceived to hold great future possibilities for the study of medicine. This intermediate year was spent jointly at the Sheffield Scientific School and at the Yale Medical School. In the former, Welch came under the influence of Professor Oscar H. Allen who strongly stimulated his interest in science in general and in chemistry in particular. This rather unconventional and solitary personality, who was not only chemist, but geologist, mineralogist and botanist as well, proved to be an inspiring teacher. At the Yale Medical School the professor of chemistry was George Frederic Barker, afterwards professor of physics at the University of Pennsylvania and a member of the National Academy of Sciences, who was deeply interested at the time in organic chemistry and thus turned his pupil's attention to the writings of Kekulé which were just then exerting a dominant influence on chemical thought. Within the year the student was mastering the concepts of Kekulé in the original German. The breadth of interest of the two able teachers under whom Welch had the good fortune to come during this preparatory year, may well have exercised a directive if latent influence on the gifted and impressonable pupil which at a somewhat distant day was to assert itself in the determination to break with the traditional and alluring career of private and consultative practise, and to embark upon the hazardous one of pathology. This decision was not, however, arrived at immediately or even at the outset of his medical work, but came later as part of a widening knowledge and an enlarging experience.

It was fated also that the two men who, each in his own although different way, were to influence the rise of pathology in the United States, should first come together in the chemical laboratory of the Sheffield Scientific School. T. Mitchell Prudden had gone through the school at about the time when William H. Welch passed through the college; but as in that day the two sets of students—academic and scientific—rarely met and never mingled, the two men were not brought into contact. When Welch entered the laboratory, Prudden was already there, filling a kind of voluntary instructorship; and thus the two men whose paths were to cross and recross in the many subsequent years of sympathy, perfect understanding and common endeavor, first discovered in each other, albeit still in embryo as it were, that devotion to science and its ideals which as the years lengthened was to prove secure against the many and insistent allurements and pecuniary rewards of medical practise.

The year of chemical study over, Welch returned definitely to his medical studies. It will aid us a little later in the understanding of the change about to be wrought in the pursuit of pathology—in the making of advances in which the then unsuspecting medical student was to play so large a part—if we pause to sketch in broad outline the kind of educa-

tional discipline offered the medical student at the College of Physicians and Surgeons, a leading institution, in the period embraced by the years 1872 to 1875.

In 1872, when Welch entered, the College of Physicians and Surgeons had been in operation for sixty-five years and led all its competitors in the number of its students and in teaching facilities. The college occupied a building of its own on Twenty-third Street, regarded as commodious, and was a part of Columbia University. The term of instruction had been extended from four to five months, and three instead of two sessions of attendance upon lectures were required for graduation. The precarious supply of material for dissection and for instruction in operative surgery and the method of obtaining it had been superseded and made fairly adequate by legal enactment. The courses in anatomy and to a less degree those in medical chemistry comprised the entire provision for objective or practical teaching, aside from the out-patient clinic at the college and the clinical lectures given at the New York and Bellevue Hospitals and the Almshouse. A voluntary course of lectures on pathological anatomy with demonstration of organs removed at autopsy was offered during the summer session by Francis Delafield.

While the preceptorial system was still in vogue and the medical student was still expected to obtain the main part of his clinical training during the long interval between sessions, in the office and on the rounds of his preceptor, the few outstanding students could hope to enter Bellevue Hospital for an interneship, which might begin even six months before graduation. But the didactic lecture, of which the instruction still chiefly consisted, was expected to fill the mind of the student with the medical lore of the day, while it served also to impress his imagination with the vigorous personality and high authority of the eminent teachers under whom he sat, in a manner now wholly foreign to the spirit of medical teaching.

But to the able, energetic and ambitious student the plan, imperfect as it was as an educational discipline, admitted of a choice of subject and disposition of effort not contemplated in the system. And thus we find Welch in the early period of his medical studies enticed away from the lecture halls into the more alluring atmosphere of the dissecting room and very soon serving as prosector to the professors of anatomy.

With the curriculum as indicated, it is obvious that no opportunity existed to acquire thorough training in any subject, aside possibly from the grosser aspects of human anatomy. The provision for pathology was extremely meager. Although a chair of physiology and pathology, filled by Alonzo Clark, had been created in 1847, in the early seventies of the last century, pathology had not become an independent subject of teaching, but was attached to the chair of medicine, still, as it happened, under Dr. Clark, who had been transferred to the professorship of pathology and clinical medicine.

There is no reason to suppose that Clark treated pathology otherwise than by lectures, with perhaps at most the occasional use of specimens from the deadhouse. On the other hand, Francis Delafield, who had become adjunct professor of pathology and clinical medicine, was already studying assiduously with the microscope the pathological changes in the kidneys in Bright's disease and still other morbid processes, as viewed indeed from the standpoint of the new cellular pathology just struggling into the light. But of opportunity for the student himself to acquire even the rudiments of the technique of the microscopic study of the organs and tissues in health and disease, there was none. It was not, therefore, just at this juncture in Welch's history that his interest in pathology asserted itself.

A compelling circumstance was, however, imminent. Among the prizes offered to students was one provided by Dr. Seguin, then the professor of diseases of the nervous system, for the best report of his clinical and didactic lectures. It consisted of a Varick microscope fitted with superior French triplex lenses. This prize was won by Welch, and it

proved indeed to be the spark which ignited the tinder of his latent interest in pathology and caused it to burst into flame. Fortunately Welch now entered in October, 1874, upon his interneship at Bellevue Hospital, where this strongly aroused impulse was to find an abundant field for expression. He now also came more directly under Delafield's influence, and was thrown with the elder Janeway. Much of his time was spent in the deadhouse performing autopsies, first on his own and then on many other cases; and it is a remarkable tribute to his technical skill and acumen of observation, as well as felicity of description, that Delafield invited him to use his special book for recording the protocols of the postmortem examinations, and that he was made a curator of the Wood Museum attached to the hospital.

Although it was perhaps not clearly perceptible at the time, it now appears that the circumstances surrounding and thus acting upon the sensitive imagination of Welch, the student, were favorable to his development; for notwithstanding the poverty of material resources and of laboratory facilities of the era, he had the good fortune to come under the influence in the medical college of not a few men of remarkable mental vigor and attainments. Besides those already mentioned, there were on the faculty of the college in his day Dalton and Curtis in physiology, St. John and Chandler in chemistry, Edward Curtis in materia medica, Markoe in surgery, Sands and Sabine in anatomy and McLean in obstetrics; weekly clinical lectures were given by Willard Parker and T. Gaillard Thomas, the prestige of whose strong personalities and eminent careers in surgery and in obstetrics and gynecology respectively must have been potent forces. He was thrown as prosector into close association with Sabine and with the demonstrators of anatomy, John Curtis and McBurney. It was especially at the suggestion of Sabine that Welch wrote his graduating thesis upon goiter, which received the first prize, and in the preparation of which he familiarized himself with medical literature and bibliography at the New York Hospital Library. At Bellevue Hospital his contacts with Delafield and with Janeway became numerous and close, the forerunner, as it chanced, of a relationship destined to become even more intimate and significant at a somewhat later period.

Moreover, the era in which the young student found himself was one of fundamental flux of belief brought about by the new cellular pathology and the discoveries of Pasteur just impending. Into this whirlpool of shifting ideas, which were to move in the next succeeding years with ever-increasing speed, Welch with his eager, open and responsive mind was thrown. That his imagination was powerfully stirred by the intellectual ferment of the time may be assumed. One circumstance is, however, quite clear: at this stage pathology as an independent career had not been seriously before his mind, nor was it so to present itself until a whole new set of experiences had been pressed through.

The year and a half's interneship over, Welch is about to take ship for what proved to be for him and us a great adventure. In April, 1876, in company with his friend and fellow townsman, Dr. Frederic S. Dennis, he sailed on the Cunarder *Bothnia* for Liverpool. From Liverpool he went to London, where he spent a few days, crossed the channel from Harwich to Rotterdam and made his way leisurely along the flowering Dutch and Belgian fields as the spring was passing into the mild early summer months, toward Strassburg, the first stopping place on the long but important road which was about to fascinate his view.

Welch's European experience begins with Waldeyer, the director of the Anatomical Institute in Strassburg, with whom he studied normal histology. This subject was of course taken up on account of its fundamental importance as a basis for pathological histology. But it is significant that the interest in chemistry, also as a foundation subject, which carried Welch to New Haven on the very threshold of entrance to his medical studies, had remained alive; hence part of his time

was spent in Hoppe-Seyler's laboratory, under the master himself and his assistant Baumann, in working through the former's well-known text-book in physiological chemistry. In addition, time was found to attend von Recklinghausen's autopsies and demonstration course, although at this period no further courses were taken with this master of pathology and for the reason that Welch concluded that until a grounding in normal histology was secured, it would not be profitable to pursue pathological histology.

The summer semester at an end, Welch left Strassburg for Leipzig, the summer vacation being spent with a friend in a pedestrian tour in Switzerland and northern Italy. It is of interest to inquire just what was the lure of Leipzig. Obviously Waldeyer was the attraction in Strassburg; now it was Heubner and Wagner who drew the student to Leipzig. At that time Heubner had not entered the field of pediatrics in which he afterwards became celebrated, but he was working rather in the field of neurology; and, indeed, it was his important book on the diseases of the blood vessels of the brain,[2] which Welch had read, that determined the choice. If we undertake to penetrate further into the source of Heubner's attraction for Welch, we are led back to the days at the College of Physicians and Surgeons in New York and the lectures of Seguin which had exerted a strong influence on Welch, so that if we had then inquired whither he was tending in medical specialization we should have discovered that he was looking to diseases of the nervous system as the field for practise, while pathology remained his main interest and subject of training in Germany, although he could not then anticipate its pursuit as a means of livelihood on his return to America.

Circumstances were, however, to defeat this consciously worked out program. In due course Welch subscribed for Heubner's course, only to find very quickly that the latter was not then interested in teaching; soon the course began to languish and the students to absent themselves, and it was not long until Welch was looking elsewhere to fill his time. Wagner, who later succeeded Wunderlich in the chair of internal medicine, was at the time professor of pathological anatomy. Welch found Wagner's courses and the opportunities afforded for independent work by his institute admirably adapted for his own purpose. Here he attended autopsies and obtained specimens of tissue for microscopic examination. At first the blocks were given as a favor; but later, Wagner's interest having become aroused, he would personally select the specimens for examination and for report. In this manner Welch occupied his mornings; the afternoons were, however, still free. He attended Wagner's polyclinc, which kept him in touch with practical medicine.

At this period Ludwig's laboratory was the center of attraction for the talented men in Germany and also for many foreigners especially interested in physiology. Welch decided to offer himself and was accepted by Ludwig. That the choice was a propitious one is shown by the group of men at that time working with Ludwig and with whom Welch was now associated. The first assistant was the gifted and inspiring Kronecker with whom Welch formed an enduring friendship. Among foreign students was Pawlow, and Drechsel and Flechsig were in charge of the chemical and the histological divisions of Ludwig's laboratory. Welch was set by Ludwig to study the ganglia and nerves of the auricular septum of the frog's heart with the gold chloride impregnation method, in the course of which he actually brought into view the ganglionic cells with T-shaped fibers which Ranvier described in detail somewhat later. The semester closed and the usual *Abschied* supper was given by Kronecker. Of course Welch was invited and there was characteristically exhibited a model of the ganglion cells with fibers both entering and leaving it—a novel and as we now know a histologically highly important event.

The first year of Welch's European study was now over. It had been spent in preparing himself in normal histology, physio-

[2] Heubner, "Die luetische Erkrankungen der Hirnarterien," Leipzig, 1874.

logical chemistry, pathological anatomy and physiology; and it may be asked to what purpose and for what ultimate end? The answer is, in order to be ready to study with Virchow, whose institute he had visited during a short stay in Berlin. This expectation was indeed the force back of the concentration on normal histology, the reason for embracing eagerly a histological problem from Ludwig, the motive in following Wagner's autopsy and microscopic courses; and, after all, the wish was to be frustrated and Welch's activities were to be directed along a wholly new direction and into fresh channels.

The new impulse came from Ludwig who did not share the enthusiasm, at least in the overwhelming degree then current, for the cellular pathology of the period. Perhaps this response was the less hearty because he did not have the strong sense, as so many seemed to have, of a great innovation, but rather viewed Virchow's doctrines as the extension, perhaps even the consummation, of the earlier conceptions and discoveries of Schwann, Schleiden, Remak and Reichert; or possibly it was his physiological bias or even a subtler appreciation of the impending influence of the study of function on the growth of pathology, which led him to induce Welch to alter his plans and to offer himself to the brilliant young pathologist Cohnheim to whom he undertook to write urging him to receive Welch and to furnish him with a rewarding (*lohnendes*) theme.

This choice proved highly fortunate. As one review's Welch's own published work, his immediate influence on his students, or the more general effect which his career has had on medical education, it is now quite obvious that his intellectual temper was of the order called dynamic, and his vigorous responses were to concepts built on facts of function far more than of form and structure. The summer semester of 1877 with Cohnheim in Breslau was perhaps the most delightful and satisfying of all the time Welch spent abroad; and fortunately we possess a pen picture of him at that particular time, drawn in clear and sympathetic lines.

Salomonsen, afterwards professor of pathology at Copenhagen and the present Nestor of medicine in Denmark, had also come to Breslau for the summer semester. The two foreign students, the first foreigners who studied with Cohnheim, were at once thrown together; there existed, indeed, that subtle quality in the temperaments of the two men that quickly made for close association and then intimate friendship—a rare relation which neither distance nor fleeting years have severed. Salomonsen states that the two men who most influenced his own life were Carl Weigert and William H. Welch. He goes on to enlarge and say that he and Welch had many points of contact: both were sons of physicians, both on return to their own countries hoped to become pathologists to municipal hospitals, and both regarded it as a matter of course that any one wishing to enter on the career of pathologist should aspire to work under Cohnheim.

The two foreigners were proud of the distinction—what two eager young men would not be?—of being the only foreigners in the laboratory among such present or prospective stars as Weigert, Ehrlich, Lassar, Lichtheim, Albert Neisser, Senftleben and O. Rosenbach. They were always together—from early morning to late afternoon—and they were taken up cordially by their German colleagues of whose intimate circle they made a part. I venture to quote a particularly appropriate paragraph from Salomonsen:

> That by accident I should have found so gifted a man and investigator as Welch in Breslau, I at that time, as well as later, regarded as the greatest good luck. Cohnheim knew well how to appreciate Welch, and he recommended him for the professorship of pathology at the Johns Hopkins University where Welch exerted a profound influence on the development of medical education in the United States, and where the present generation of American pathologists call him master.

It was in this remarkable atmosphere that Welch spent a precious semester. The work of the laboratory was pretty sharply divided between the autopsies conducted mostly by Weigert, and the experimental investigations

in which Cohnheim shone ever brighter and brighter. The particular problem which Cohnheim assigned to Welch was the ascertaining of the origin of acute general edema of the lungs. This is perhaps not the place to go into minutiæ of that splendidly conceived and executed piece of experimental work. It was in many ways fortunate that Cohnheim was too preoccupied at the time reflecting on his theory of tumors and in the preparation of his text-book on general pathology to do more than propose the problem which Welch developed largely according to his own notions of logical sequence. Cohnheim, indeed, was greatly surprised when, contrary to his preconception of the process, Welch found the factors involved in it to be mechanical. The masterly paper describing this piece of work as it appears in *Virchows Archiv* was written out by Welch in German and printed quite as he prepared it. Cohnheim seems not to have altered essentially the composition, the mode of presentation or the conclusions arrived at. Unfortunately for future controversy Cohnheim misconstrued the implications of Welch's experiments and in his epochal Lectures on General Pathology he substituted for the term disproportion (*Missverhältniss*) employed by Welch to express the disharmony (often caused by spasm) in action of the two cardiac ventricles, the term paralysis (*Lähmung*), which implies only one form of disharmony.

The by-products of this semester on Welch's development were as important as the direct influences. Salomonsen's studies on tuberculosis of the eye initiated him into the experimental side of the tuberculosis problem. Salomonsen relates an incident showing the great impression made upon the two foreign students by the first example of generalized tuberculosis in the guinea pig which they observed. Their enthusiasm evoked hearty laughter from Cohnheim. It was, moreover, the period of Heidenhain's early brilliant work, of the rich harvest of Cohn, the botanist; and to cap the climax, the occasion of Koch's visit to Breslau to lay before Cohnheim and Cohn the facts of his studies on anthrax in the demonstration of which all the workers in Cohnheim's laboratory were permitted to share. Finally, Weigert with Ehrlich was just applying the aniline dyes to the staining of tissue elements and bacteria and had recently completed his study of smallpox, in the course of which he demonstrated by staining methods the masses of micrococci within the pustules. Ehrlich also, although not yet graduated, was literally dabbling in the aniline stains and it was a common event to see him with hands covered up to the wrists with dyes of many colors. The close friendship of Welch with Weigert and Ehrlich dates from this period.

It is significant that the spirit of the Institute was favorable to the new bacteriology and that Cohnheim and his associates were all looking to the new science to unlock doors still concealing the origin of the diseases called infectious—an attitude striking in its difference from the skeptical and rather disdainful one of the Virchow school of pathology. Thus on leaving Breslau, Cohnheim sent Welch to Vienna by way of Prague, in order that he might visit Klebs, who was engaged in the study of acute endocarditis from the microbiological side. There he spent several stimulating days, during which Klebs showed him through his excellent museum and demonstrated his preparations showing microorganisms (micrococci) in the ulcerative lesions of acute endocarditis. The impression which Klebs made upon Welch was very strong; and in the light of present knowledge, the accuracy and prescience of Klebs' work, well in advance of his period, not only on endocarditis but on diphtheria and experimental syphilis as well, have become clearly apparent.

The next stop in the educational journey was made at Vienna which was still a kind of Mecca for foreign medical students of all nationalities. The immediate objective was a place in Stricker's laboratory, in order to continue his studies in experimental pathology. As an index of the high feelings prevailing at the time it may be mentioned that once Stricker learned that Welch had been with

the heterodox Cohnheim who taught that the pus cell was merely an emigrated leukocyte, he was not inclined to receive him as a worker in his laboratory. One purpose of the visit to Vienna was to study embryology under Schenck, but the choice was not fortunate and Schenck was soon forsaken. It is interesting to note that Welch and Prudden found themselves together in Vienna in their search for an opportunity to study embryology.

On the whole, the chief lure of Vienna for the pathologist was its almost inexhaustible store of pathological anatomical material. The reign of Rokitansky was over, and his successor was Heschl, the discoverer of the methyl-violet reaction for amyloid, but a far less significant personality. The greater attraction was the young Chiari, who was teaching and working with the vigor which afterwards became so notable and carried him by way of Prague to Strassburg to succeed the eminent von Recklinghausen. To him Welch went, but not to spend his entire time. There survived in his mind, it appears, a residue of distrust that pathology would after all afford him a career in America, or was it the love still for the more immediately practical aspects of medicine which led him to enter upon courses on the skin under Hebra, on neurology and psychiatry under Meynert, on the eye and other special subjects? But Vienna meant for Welch much more than gross pathology and the medical specialties. The great city with its splendid museums of art, its grand opera, and its vivid life introduced features of another order into his experience, feeding that general culture in literature, history, and the fine arts which came to distinguish him quite as much as his many-sided medical attainments. Welch remained in Vienna until the Christmas holidays, when he turned his steps for a second time toward Strassburg, spending a few days *en route* in Würzburg with Rindfleisch and his assistant Ziegler.

The second pilgrimage to Strassburg was the carrying out of a plan formed by Welch at the outset of his European study. He recognized in von Recklinghausen the outstanding representative of the Virchow school of pathologists, and his attendance upon the autopsies at the Pathological Institute, while he was a pupil of Waldeyer, had stimulated his zeal to work directly under the master. This desire could not be at once appeased, for as we have seen, Welch lacked the preparation in normal histology which he regarded as essential. But now that this requisite was supplied and the work with Ludwig and with Cohnheim had provided a fair foundation for further building, Welch offered himself to von Recklinghausen and was accepted.

As another indication of the commotion which Cohnheim's investigations were making in the placid waters of Virchowian pathology, it may be cited that once von Recklinghausen learned Welch was fresh from the laboratory of that heretical pathologist, he chose as a theme for his special study the inflammation of the cornea of the frog induced by various caustic chemicals. The essential point of difference involved in the contentions of the Virchow and the Cohnheim schools related to the origin of the pus cell. Was it derived by multiplication from the fixed tissue cells, or was it a leukocyte emigrated from the blood? The controversy has long been setled in favor of the latter, or Cohnheim view; but in January, 1878, and for many years thereafter it raged with vigor and even bitterness. The cornea was selected because of its condition of non-vascularity. The novel experimental procedure employed at von Recklinghausen's suggestion by Welch was the excision of the cornea after the injury and immersion in the aqueous humor of the frog or bullock, and observation continued over long hours under the microscope. That cells moved toward the injured spot in the non-vascular specimen was shown beyond peradventure and even that they divided; what was simpler, therefore, than to conclude that migration is not dependent on the presence of the blood, and hence pus cells are not translated leukocytes? This inference, however, was not drawn by Welch, who recognized that the reasoning is fallacious. The full explanation of the observed phenomena waited on later studies and even on recent

discoveries. We now know that connective tissue cells, among which the corneal corpuscles and the cells of Descemet's membrane are classed, are motile; and as cells endowed with movement they are attracted by certain stimuli called "chemical," such for example as arise in tissue constituents acted on by chemicals and in other ways. Moreover, as we now know, these fixed tissue cells readily multiply *in vitro*, and thus we arrive at the conclusion that the chemically altered spot in the cornea attracts toward itself neighboring uninjured, motile corneal and other cells, that these cells aggregate about the site of the injury and even multiply there, and thus give what may be called a spurious appearance of a collection of pus cells. For it should be remembered that we are dealing with a period in which tissues were not yet being stained with certain nuclear and other dyes that bring into view brilliant and subtle distinctions of cellular structure; but that the "inflamed" cornea was merely silvered in order that the cell outlines might become perceptible, and, if desired, was subsequently stained with hematoxylin to show the nuclei.

This practise of putting to the test new discoveries and contentions even under somewhat hostile circumstances was not a poor discipline for the future teacher of pathology in the United States. The experience may indeed be regarded as having brought into play under favoring circumstances a critical faculty inclined perhaps to leniency, while it held up as it were to the mirror of his perceptions in a somewhat summary fashion the facts of the ultimate and ineradicable residue of personal bias in all men, no matter how great. In the long future years during which Welch dispensed knowledge and, what is rarer, wisdom at the Johns Hopkins University and elsewhere, he came as near as it is perhaps possible for a mere mortal to come, in escaping the blemish of preconception and prejudice and in preserving and presenting the ideal of the open though balanced mind.

But it would be wrong to infer that there was not also a constructive side to this period with von Recklinghausen. The pathologist was great in attainments, and stimulating as a teacher. He engaged Welch in discussion of many topics in pathology which were current at the time. One of these related to the origin of tumors, regarding which von Recklinghausen was endeavoring to formulate his views along lines which have since become more familiar. He inclined to the conception that a kind of fertilization, whether by conjugation or otherwise, took place among the cells, leading to the unconstrained multiplication characteristic of cancer and other tumors, in consequence of which irregularities of division arose that were the striking obvious signs of the cellular abnormality. Welch always retained an admiration for von Recklinghausen as a great pathological anatomist.

The first European adventure was now approaching its conclusion and was to receive a suitable ending by a first visit to Paris and a second to London. It is far simpler and more satisfying perhaps to leave to the imagination the picture of Welch in the great and beautiful French city with its wealth of present interests and of historic backgrounds everywhere insistent. The fact may, however, be mentioned that time was found during the two or three weeks of his stay to hear Ranvier, whom he admired greatly and whose book on histology had been his guide, and to visit the main hospitals. In London he heard Lister lecture at King's College Hospital, and shared in the prevailing excitement which arose from Lister's daring surgical exploit of opening the knee joint. The next was the final act, namely, taking ship at Liverpool for the United States.

The arrival in New York in the spring of 1878 brought forward a question which could be permitted to remain in the background in Europe, but now must be answered. Undoubtedly Welch possessed wares garnered at home and abroad—but to what market were they to be taken? That the practise of medicine would be a necessary corollary to any other ambition he might indulge, seemed never to have been doubted by him. Where else were the necessary pecuniary rewards to come from? There seemed no alternative but to decide im-

mediately whether he should choose New York or Norfolk as a field of operations. In Norfolk his father was still busily, if not very remuneratively, engaged in country practise, in the course of which he dispensed much kindness and, according to tradition, worldly wisdom with his medicines. It strikes one now as very odd that Welch should have hesitated at this juncture in his choice of New York or of Norfolk. The anomaly can best perhaps be explained by taking into account his remarkable modesty. It seems almost impossible of belief that one so gifted and innately so forceful should not be aware in some degree of the part which nature had cast for him. But whatever pangs of indecision he may have suffered were about to be allayed by destiny in the form of Dr. Goldthwaite.

Success in attaining interneships in hospitals or appointments to the medical services of the Army and Navy was still determined by the results of competitive examination. To meet this situation the private "quiz" had arisen and operated about the medical schools and upon the aspiring medical students. The practise has now been generally discredited and discontinued; but in 1878 and for many years afterwards the "quiz" if successful was a reputable and a relatively highly remunerative affair. The "quiz" masters adapted the cramming process to the peculiarities and foibles of the individual examiners, which they sedulously set themselves to learn. It is now obvious that on joining Goldthwaite's "quiz" Welch never regarded the undertaking as more than a stop-gap. It should not now surprise us to learn that the combination of Goldthwaite and Welch proved irresistible and soon outdistanced all competitors; it could choose the most promising students and its product gained the prize interneships. Welch endured the "quiz" three years, after which and while it was at the height of its popularity he withdrew. The reason is sufficiently apparent now, but then with the system intrenched as it were, it required insight and force to convict it of its salient defect, namely, that of being a bad method, viewed from the standpoint of educational discipline.

The "quiz" was, after all, merely an incident, the main import of which was that it ensured the necessary income, while leaving much of Welch's time for more engrossing pursuits. As a matter of fact, Welch had offered himself for practise and occupied at this period rooms with his friend Dennis at 21 East Twenty-first Street, adjacent to the office of his old teacher, Alonzo Clark, who would refer occasional patients to the young men. The volume of Welch's practise never became embarrassing, so that he was still free to follow his major bent, which was to teach pathology.

The outlook for pathology in New York in 1878 was not bright. The extent and the nature of the teaching had not changed materially since Welch was a student in the medical college. New York was as much cut off from the strong currents moving in Germany and France along the three main lines of pathology—pathological anatomy, experimental pathology and bacteriology—as if Europe and America were not connected by a common intellectual bond. Welch was, indeed, destined to play the principal part in breaking the barrier of American isolation, but at this time when he was offered by Dr. Francis Delafield the lectures on pathology during the summer semester at the College of Physicians and Surgeons, he declined the opportunity, because it carried with it no chance to set up a laboratory, which was the one essential of Welch's aspiration. But what was denied him at the College of Physicians and Surgeons was about to be put before him at Bellevue Hospital Medical College. This rival institution proposed to build two small rooms over a hallway, which, added to another room, Welch could turn into a laboratory.

The invitation was accepted at once, and Welch made his first break with the established traditions in New York. For this was the heyday of schism in medical schools and feelings ran high among the several faculties, and the position of his alma mater, the "P. and S.," in the medical hierarchy of the time was regarded as supreme. Certain of Welch's friends were not happy over his choice and even considered that he had made "the mis-

take of his life." Perhaps there were disadvantages of a kind in a Bellevue connection as contrasted with the far greater prominence of the "P. and S." establishment, but whatever they may have been in general, they were more than compensated for by the laboratory and its proximity to the deadhouse at Bellevue. The new pathological laboratory became at once an influential factor in the medical educational system of New York, and students came there to Welch from all three medical schools.

The leaven worked rapidly; for very soon the College of Physicians and Surgeons awoke to the growing demands of pathology. A part of the faculty had not ceased to view Welch's defection regretfully, and now that the Alumni Association proposed to set up, under Delafield's general direction, a pathological laboratory, its direct conduct was offered at Welch. The invitation was not accepted, but in declining it Welch characteristically, as we should now say, put in another strong stroke for pathology, as the following letter, which also explains his sense of obligation to the Bellevue College, illustrates:

NEW YORK, October 9, 1878.

My dear Dr. Prudden: A few days ago Professor Delafield told me of the following scheme which the Twenty-third Street Medical College has on foot. A laboratory for histology and pathology is to be established in connection with the college, by means of a fund given for the purpose by the alumni. It is to be taken hold of in an earnest way, for the laboratory is to hold the same relation to the college as the dissecting room does; that is, each student will be obliged during some part of his course to work there before he can take his degree. Dr. Delafield proposed that I should go in as his first assistant and have charge of the histological department, and assist him as much as necessary in the pathological part. The salary was to be five hundred dollars for the first year, and I believe more subsequently. I was naturally delighted with the offer and thought it to be just what I wanted, an opportunity to work in the direction where I had studied most. Upon speaking of the matter, before coming to a decision, with some of the professors at Bellevue, I find that they are reluctant to have me leave there, and even represent it as not the square thing for me to go at present. The latter motive especially has influenced me to stay, as I do not believe it pays to do anything unfair. I feel as if I were relinquishing a great opportunity and do not see any equivalent for it at present at Bellevue, but as there is a feeling there that it would not be right for me to leave, I am going to stay and have so told Dr. Delafield. He asked me if I knew any one who would be competent for the position, saying there are a great many in New York who think they are, but few who really are.

I immediately suggested your name and he at once seemed pleased, and deputed me to hunt you up by a letter and communicate the proposal to you. I really think the offer an advantageous one, in fact presenting an opportunity better than any other I know for one with the tastes and resolution which you have formed. I do not know any one who could do greater justice to the work there than yourself, and it seems to me to present great possibilities for the future. Personally I should like to have you here in New York, for I fear I am going to rust out unless I have some one to talk with and help me on concerning the subject in which we are both interested.

I do not know whether this letter will even reach you. Will you at least drop me a postal card when you receive it, for if I do not hear from you in a day or two, I am going to resort to further means of hunting you up. I should also like to know how you decide.

With Prudden's installation at the College of Physicians and Surgeons, pathology had come to be recognized as a subject of independent merit and proportions, to be taught practically, by two of the leading medical schools of the country. Prudden was a pupil of Arnold of Heidelberg, under whom he had mastered a precise and delicate pathological histological technique; and later at Vienna, in part alongside Welch, he had imbibed the essence of the teaching of morbid anatomy. Thus and at last in the persons of Welch and Prudden, American pathology had come to be united with the best sources of its inspiration abroad; and from now on the main task was to widen and diversify this stream in the accomplishment of which purpose Welch's career stands forth preeminent.

Welch was now fairly launched on a career

in pathology, but his struggles were not all over. The serious question all along was the economic one. Pathology was not a remunerative profession at the time. The fees from students taking the course were small, the occasional windfall from a private autopsy was precarious. There were, of course, the fees for the examination of specimens for physicians and surgeons and the possibility existed then as now of turning this practise into considerable income. But Welch shrank from an enterprise which would consume his time and yield no corresponding scientific return. After the abandonment of the "quiz" a way out was found in that he became, first, assistant demonstrator and later demonstrator of anatomy at Bellevue, both paid positions; and then he offered himself for practise. That his neighbor and teacher, Alonzo Clark, sent him patients, we have seen; it remains, however, to add that the now elderly gentleman formed the habit of referring his surgical cases to Welch.

This was also the period of Welch's association with the elder Flint, then at the zenith of his prominent career as teacher and consultant. He was professor of medicine and the leading spirit at the Bellevue College, and a great social and professional figure in New York. Flint was engaged at the time in bringing out a new edition of his Practise of Medicine and asked Welch to revise the sections on pathology. Welch "jumped at the chance" and was given a free hand, except for two or three topics which were reserved for his son, Austin Flint, Jr. Any one to-day reading Flint's Practise of Medicine will recognize the superior merit of the introductory chapters on general pathology and the sections on the pathology of the special diseases there given, the whole amounting to a text-book on pathology.

It was Flint's habit to precede his lectures on "practise" with a sketch of the pathology of the subject to be presented. Pretty soon these preliminary lectures were turned over to Welch, who lost apparently no opportunity to increase the prestige of pathology in the curriculum. Thus he introduced the class autopsy, which he held once a week in a room filled with students. Notwithstanding these clear indications of Welch's unmistakable bent and trend, Flint assumed all along that Welch would become a consultant and succeed him in the professorship of medicine. Indeed, he took steps by having the faculty elect Welch to the clinical professorship of medicine to make his succession certain. Welch on learning of this action brought about its revocation, first, because of the injustice which he considered done to the then incumbent of the clinical professorship, and next because of his great interest in pathology.

Looking backward it can be perceived that these many shifts and activities were incidental to the laboratory of pathology. First, the "quiz"; second, the demonstratorship in anatomy; third, practise—each in turn supplied the necessary income in money to cover living expenses. Each in turn was followed with energy and success, and abandoned as soon as the needed income was available from a source less exacting of the precious time to devote to autopsies and laboratory, or freer from considerations violating fundamental beliefs in sound educational method. Pretty soon his skill in performing autopsies and his eagerness for pathological material brought to Welch privileges from the Babies' Hospital and also from the coroner, with whom Welch stipulated that he was not to testify in court. It is of passing interest to note that none of these were paid positions, but that at this time a small stipend came to Welch from the registrarship of the Woman's Hospital, which position he then held, and where he made the autopsies and studied the specimens, mainly ovarian tumors, removed at operations.

Half a dozen years had passed since his return from the European studies, and Welch had intrenched himself deeply in the medical life of New York. He was the outstanding pathologist and representative of the new pathology, and there came to him to study or to work, the alert and ambitious among the medical students and young practitioners of the day. These years had contained not a little that was pleasant, but much also that was discouraging to one who possessed a deeper feel-

ing for and a wider outlook on medical education. It is true that improvements were creeping into the medical curriculum; the annual sessions at this time were indeed extended from five to seven months and more emphasis was being placed on the laboratory and less on the purely didactic form of instruction; but progress was painfully slow and medical teaching lagged sadly behind that of continental schools. However, a turn in medical affairs was impending which was to transform within a few years the entire educational structure.

The Johns Hopkins Hospital was approaching completion and the thoughts of President Gilman and the boards of trustees of the Johns Hopkins University and Hospital were turning toward the establishment of the medical school provided for in the splendid gift of Johns Hopkins. A leader to guide the new enterprise was sought, and it is quite clear from Salomonsen's statement that President Gilman asked Cohnheim's advice, and doubtless the advice of others at home and abroad. Welch seems to have been the unanimous first choice. Dr. John S. Billings, so intimately associated with the planning of the hospital, visited Welch at Bellevue, doubtless in this connection, and Welch was invited to become professor of pathology in the university and pathologist to the hospital. The great opportunity for which he had waited and labored and toward which his dearest aspirations turned had now come to Welch.

There was no doubt in Welch's mind that the Baltimore venture was full of promise and should be embraced. In the meantime, however, his position in New York had become so important, it is not surprising that a strong effort should be made to retain him. At first Welch's friends failed to see how any one could exchange the professional opportunities of New York for those of provincial Baltimore. The incidents of the transition from the "P. and S." to Bellevue College were recalled in this almost grotesque adventure. But there was no doubting Welch's seriousness, and hence steps were taken at once to thwart his plans. The fear of losing Welch was the immediate incentive which brought the Carnegie Laboratory into being. Dr. Dennis, an intimate friend and admirer of Welch, obtained a sum of $50,000 from Mr. Carnegie for the erection of the laboratory. But there is reason to believe that Dr. Dennis had in mind, besides the purpose of anchoring Welch to New York, the setting up of the laboratory as an integral part of the medical educational system of the United States.

But the Carnegie Laboratory was, after all, a building only, with such simple and necessary equipment as was demanded by the work of the period in pathological anatomy and in bacteriology, just at its beginnings in the United States. There was no provision made for a paid staff, and there were no funds for daily running expenses. Just what might have happened had these essentials been provided, it is impossible to say, for undoubtedly with the erection of the Carnegie Laboratory the outlook for pathology in New York had suddenly brightened. But the vista opened before Welch's eyes at Baltimore was extremely fascinating, and strong as now may have been the motive to remain in New York, the unprecedented position which the Johns Hopkins University, at the zenith of its great reputation, had attained in fostering science, was a lure not to be resisted. Everything about the opportunity at Baltimore attracted Welch, who wished above all to be free to develop pathology in a manner approaching that which he had come to know in Germany; and fortunately for the history of medical progress in the United States, he yielded to manifest destiny, although in doing so he was breaking with old and devoted friendships and turning his back on a position in New York never yet attained by a devotee of a laboratory branch of medical science.

In the six years which had elapsed since Welch had returned from his first period of foreign study, the center of interest had begun to shift from the purely cellular pathology of Virchow to that of the microbiology of Pasteur and Koch, in which the bacteria appear as the direct incitants of disease. Here at last, it seemed, were to be discovered the

agencies whose actions are the immediate excitants of those organic and cellular changes or lesions constituting the visible reactions of the tissues to the injurious influences taking place in the course of the phenomenal process designated disease. This new direction of development was highly sympathetic to Welch who had been a spectator at Breslau, at the prologue to this swiftly moving drama, when Koch visited Cohn and Cohnheim in order to exhibit his anthrax cultures. Welch desired first-hand knowledge of and experience in the new field, and as the Johns Hopkins Hospital was still in process of construction, we find him setting out again, in the summer of 1884, for Germany.

The new goal was Koch in Berlin. But an interview with him at the *Reichsgesundheitsamt* led Welch on Koch's advice to go to Munich for the autumn to study under Frobenius in Bollinger's laboratory, preparatory to work under the master at a later date. It appears that Koch was soon to leave the *Gesundheitsamt* to be established in the Hygienic Institute under university auspices, near the Alexanderplatz. Frobenius proved a slavish teacher of Koch's technique, which he communicated to his pupils along with such comments as he had gleaned from conversations with Koch. Still, it was a beginning in the new field and the relatively unfavorable conditions led again, as once before at Leipzig, to connections of great future importance. Here Welch made the acquaintance of Hans Buchner and also of Escherich, Lehmann, Neumann, Celli and others who had come to follow the first course in bacteriology given in a university. Especially with Celli, who had already begun his studies of the malarial parasite, he formed an intimate and enduring friendship. Welch followed at this time Kitt's demonstrations in animal pathology in the veterinary school and worked in von Pettenkofer's institute of hygiene with the master himself and his assistant, Renk. All was grist that came to Welch's mill for in after years the former experience was to bear fruit in his important studies on the swine diseases and the close interest in Theobald Smith's work, and the latter to contribute to that comprehensive grasp of the subject of hygiene now being embodied in the new school of public health at Baltimore, his latest and highly remarkable creation.

Welch did not go at once from Munich to Berlin but acting still under Koch's direction went in January to Göttingen to work under Flügge, who was professor of hygiene and much closer to Koch and being advised by him. This period was in every way advantageous, as Flügge was a far more inspiring and systematic teacher than Frobenius, and his influence proved lasting and valuable. Here again he became acquainted with fellow students gathered in Göttingen for the same purpose, who afterwards became distinguished bacteriologists, such as MacFadyen, Nicolaier and Wyssokowitch.

The final touch in Welch's preparation in the new bacteriology was administered by Koch—a vivid teacher—who himself conducted the courses, which he had previously organized for military doctors which had such far-reaching consequences. Fortune again threw Welch and Prudden together, for the latter who had taken over the laboratory at the College of Physicians and Surgeons established by the Alumni Association, was now in Berlin also seeking training in the new science of bacteriology. The course, which was of a few weeks' duration, consisted essentially in the practise of isolating bacterial species by means of Koch's solid culture technique or by passage of them through the animal body, in order to effect separation of virulent from other varieties, and in the consideration of form, staining reactions and physiological and pathogenic propensities. The climax of the course was the study of the bacillus inducing Asiatic cholera. At this period not a little apprehension existed that Europe might again be visited by that scourge. The disease had raged in India and Egypt and the year before had gained a foothold in Europe in certain Mediterranean ports—hence the desirability of mobilizing a small army of trained bacteriologists to combat that plague should it threaten in earnest. Koch himself was deeply im-

pressed with the danger; indeed so appalling did he consider the calamity of an epidemic outbreak of cholera in Europe that he did not trust himself to bring with him to Berlin cultures of the bacillus isolated in India or Egypt, but preferred to destroy them lest by inadvertence they should gain access to food or water. Now, however, that cholera actually existed on European soil and danger of its spread was imminent, the circumstances not only justified but compelled instruction in its bacteriological detection, and for this purpose he went to Toulon to secure anew fresh cultures.

But Koch admonished his pupils not to carry away from the laboratory living cultures of cholera bacillus. This piece of sound advice, following the end of the course at a *Kneipe* held in honor of the *Geheimrath* led to an amusing incident. The next morning Welch and Prudden met accidentally at an early hour on one of the bridges spanning the Spree, each, as it seems, seeking secrecy. It developed that each had gone to an apothecary's shop and purchased concentrated sulphuric acid (or was it a saturated solution of corrosive sublimate?), which they had poured over the surface of tube cultures of the cholera bacillus originally intended to take with them to America and that they now proceeded to drop into the Spree. They expected, of course, to see the tubes sink immediately out of sight, instead of which they had the momentary disquieting experience of observing them bobbing up and down as they slowly floated down stream. The guilty pair hurried away, just, it is said, as a large *Schutzmann* appeared on the scene.

An impression of Koch and the influence of his instruction at the time is given by Prudden:

> Thus the course in the study of bacteria, of one month's duration, in Koch's laboratory was brought to an end, and the writer can not refrain from remarking that the calm, judicial mind of Dr. Koch—the master worker in his field—his marvelous skill and patience as an experimenter, his wide range of knowledge and his modest, unassuming presentation of his views are all calculated to inspire confidence in the results of his own work, to stimulate his students to personal exertion in this field, and to lend certainty to the already widespread hope that ere long through the resources of science we shall be able to cope successfully with those most terrible and fatal enemies of the human race—the acute infectious diseases.[3]

Welch arrived in Baltimore in September, 1885, and there found Councilman at work in pathology. He immediately joined Welch and together they set up a laboratory in a couple of rooms on the top floor of the biological laboratory, offered them by Newell Martin. The two-storied building at the hospital, designed as a deadhouse, was hurriedly completed and converted into a pathological laboratory. This arrangement was intended merely as a stop-gap in the emergency and until the buildings for the medical school, then expected soon to be organized and constructed, could be provided. As it happened, the consummation of the medical school project was long delayed and the small quarters intended merely for a deadhouse and its essential adjuncts, became the permanent home of the pathological department, as well as indeed the actual physical foundation on which were later erected two additional stories to house temporarily the departments of anatomy and pharmacology of the medical school. When in a few years those two departments secured elsewhere other and more adequate quarters, the pathological department spread through all the vacated space, which, in view of its expanding activities, was sorely needed.

The history of the pathological department of the Johns Hopkins University and Hospital, that was to play so profound a part in the educational progress of the United States, dates from 1886, at which time Welch began to exert the influence which peculiarly distinguishes his career from that of his predecessors in this country and elsewhere. Hitherto there had been abroad departments or institutes of pathology by which was usually meant pathological anatomy and his-

[3] Prudden, T. M., on Koch's method of studying bacteria. Report to the Connecticut State Board of Health for 1885, pages 225–226.

tology, and sometimes experimental pathology or bacteriology. Welch's receptive and constructive mind responded powerfully to the training he received in these several branches of science, so that he became master not of one branch only, but of all. Thus it came about that in setting up the pathological department in Baltimore he inevitably, and doubtless unconsciously, employed all these resources of knowledge and progress, and in so doing inaugurated a new era. Hereafter pathology, at least in the United States, could hope to develop symmetrically, utilizing for its advancement the materials and methods not of one branch of the science merely but of all branches, main and collateral, which being directed toward it might suffice to render a pathological phenomenon more comprehensible or afford the solution of a problem in medicine otherwise elusive.

The purpose when Welch was called to Baltimore was to proceed immediately with the selection not only of the staff for the Johns Hopkins Hospital but of the faculty of the medical school as well. Unforeseen economic conditions postponed the realization of the latter design; but as the hospital's resources had not been reduced by the unhappy accident which crippled the finances of the university, a clinical faculty was brought together. Welch's part in the choosing in 1888 and 1889 of Drs. Osler, Halsted and Kelly was conspicuous and decisive, just as later with the opening of the medical school in 1893 it was his acquaintance with their work and his unerring judgment of them as men which added to the distinguished trio Drs. Mall, Howell and Abel in the completion of the first major faculty of the Johns Hopkins Medical School. But Welch did not await the opening of the hospital or the consummation of the plan for a medical school to start active teaching and to get under way problems of research. Work was begun in an informal manner with medical graduates and advanced students in biology, and the quality of the material and the effects of Welch's influence can be gathered from the list of names of the first group to assemble under him. In it were Councilman, Mall, Nuttall, Abbott and Bolton. Before long this informal plan was superseded by systematic courses in pathology, including pathological histology and bacteriology, and university lectures. These were not permitted, however, to degenerate merely into short, superficial series of demonstrations, lectures and exercises; but they always carried with them the freshness of the unexpected from the wide variety of activities going on in the laboratory and also the incentive to individual endeavor when any new point arose exciting to some one's curiosity.

With the founding of the medical school along the lines now familiar but none the less at that time novel to the point of revolution, the break with the past was complete and the aspiration which for so long kept Welch a student and a teacher was to be realized, and in full measure. Henceforth medical education in the United States was to be on a basis equalling at least the best continental model. The faculty of the medical school was to lose its local and provincial character and to be representative of the most potent forces in the country, while the young men and women seeking to enter medicine were to possess a foundation training in physical, chemical and biological science and to be equipped so as to follow in the original tongues the greater scientific medical literatures of the French and the Germans. This was revolution indeed; but like all of Welch's reforming acts it was a program of construction not of destruction. Welch's career stands forth supreme as a force for advancement, whether in research, education, hospital organization or public health; but one searches in vain his writings or the records of his public utterances for evidence of vehemence or denunciation. His was too understanding and sympathetic a spirit to judge men and things harshly for faults and shortcomings, the origins of which were sunk deeply into a past whose circumstances were so unlike those of the present. He made use rather of the gentler art of persuasion by exposition and example, leavening now here and now there,

until the cumulative power of the intellectual and social ferment induced became so great as to be irresistible, and the whole mass was moved forward.

From the outset Welch was the central figure and guiding genius of the medical group. The pathological laboratory became an active center of research and teaching. Welch's life quickly became filled to overflowing. He conducted investigations of his own, launched others on productive themes, and saw to it that the invaluable pathological specimens from the surgeons and gynecologists were made use of to advance knowledge and train a generation of special pathologists in those important fields. He lectured on special and general subjects in pathology and bacteriology in a manner so learned and fascinating as to produce impressions not only immediately stimulating to his auditors in high degree but of enduring permanence. The suggestiveness of these lectures led frequently to new undertakings in research. Moreover, the autopsies he performed, his demonstrations of gross pathological specimens and his teachings at the microscope stand out as unsurpassable models. He entered also into the medical activities of Baltimore and of the state of Maryland, and became a great influence for betterment in private and public medicine. He was, of course, the first dean of the medical school and guided the policy of the new institution into the productive channels that have so eminently distinguished it. His many talents were therefore called into constant play, and heavily overtaxed as they must often have been there was never indication of exhaustion. When occasion arose he was always ready, eager and able for a new advance, as witness his leading part in the recent development of the full-time system, so-called, in the clinical branches of medical teaching, in establishing a model school of public health and hygiene, and in serving on scientific and philanthropic boards possessing great wealth, for promoting scientific discovery and for carrying the benefits of medical knowledge to the furthest parts of the world.

The achievements of Welch as an investigator, teacher and reformer in medicine are so many and varied that it is not possible to do justice to them in detail in a mere sketch. This is particularly true of that part of his career covered by the Baltimore and Johns Hopkins period. These three noble volumes of his collected papers and addresses are the best expression of his many-sided activities. And yet precious as they are, they afford no real insight into Welch's almost flawless personality, the depth of his friendship and wealth of his kindness, his faculty of intense application and devotion to the work in hand whether in laboratory or in public interest, his commanding influence and guiding spirit over the work of his associates and many pupils, the stimulating wholesomeness of his public activities, and his rarely unselfish and tolerant nature which led him to shower his great gifts prodigally and far and wide. The recipient of almost every honor in the gift of his colleagues, he fortunately, in time, saw the return of his labors, increased many-fold, enriching science through progress made in education, in deeds performed and discoveries by the men and institutions over whose destinies he had presided. And lastly these volumes fail to show us still another side of Welch's accomplishments as remarkable almost as those of the science we so love to laud in him. I refer to his culture outside the realm of medicine in the field of literature, in which he possesses an almost unerring taste for the best in poetry and prose, and in the domain of the fine arts. His mind is indeed stored with the beautiful creations of other men's minds from ancient times to our own day. It is to all these remarkable qualities, innate and acquired, united in one man, that we owe that thrice rare personality William Henry Welch, master in medicine and beloved of men.

SIMON FLEXNER

THE STRUCTURES OF THE HYDROGEN MOLECULE AND THE HYDROGEN ION

IN a letter to SCIENCE published June 18 I described a model for the helium atom which

is in better accord with the chemical relationships of helium than is the model proposed by Bohr. It leads to a value 25.59 volts for the ionizing potential in agreement with experimental determinations while Bohr's theory gives too high a value. In the model which I proposed the two electrons move in separate orbits in a plane containing the nucleus. The electrons are always symmetrically located with respect to a second plane which passes through the nucleus and is perpendicular to the plane of the orbits. Each electron thus oscillates back and forth along an approximately semi-circular path.

We may conceive of the hydrogen molecule as having a similar structure except that there are two nuclei. The electrons may thus move in separate orbits in a plane which is perpendicular to and bisects the line connecting the nuclei. The positions of the electrons at any time are symmetrical with respect to another plane which passes through both nuclei. Starting from two points on opposite sides of the center of the molecule, we may imagine the electrons to revolve about the center in opposite directions. After something less than a quarter revolution the electrons come so close to one another that the repulsive forces between them bring them both to rest. These forces then cause them to return back along the same paths to the starting points. They then continue their motion and complete another quarter of a cycle before they again come to rest. Each electron thus oscillates along a nearly semi-circular line.

On the basis of the classical mechanics, by a series of approximations, it is possible to calculate the size and shape of the orbits and the relative velocities of the electrons at any point in their paths in terms of the distance between the nuclei. If we let a be the distance from the center of the molecule to the mid-point of the nearly semicurcular orbit of the electron, then the distance between the nuclei is $0.619 \times a$ and the radius vector of the electron at the ends of the orbit (where the electron comes to rest) is $1.152 \times a$. The angle through which the electrons move is 71° 26′ each side of the mid-point as measured from the center of the molecule. The angular velocity of the electrons at the mid-points of their paths is such that if they continued to move with this velocity they would travel through 106° 00′ during the time that they actually take to move to the end of the orbits (*i. e.*, through 71° 26′). The total energy (W) of the molecule (kinetic plus potential) is found to be $1.604 \frac{W_0 a_0}{a}$ where W_0 is the corresponding energy for the hydrogen atom according to Bohr's theory and a_0 is the radius of the electron orbit in the hydrogen atom (0.530×10^{-8} cm.).

It should be possible by means of the quantum theory to determine a, and fix the absolute dimensions of this model. But, so far as I know, the quantum theory has not yet been formulated in such a way that it can be applied with certainty to the type of motion that we are here considering. The quantum condition $\int pdq = nh$ is only valid when the co-ordinates are chosen in a particular manner, and for a case like the one in hand I have not been able to find any general method for determining what system of coordinates should be used. It may be, however, that others having greater familiarity with the recent mathematical development of the quantum theory will be able to determine the value of a for the model under consideration.

I have therefore proceeded to calculate the value of a from the known heat of dissociation of molecular hydrogen into atoms, and then to test this result by calculating other properties of hydrogen. Taking q the heat of dissociation (at constant volume), as 84,000 calories per gram molecule we find that $W/W = 2.270$. Since q is proportional to $W - 2W_0$ it takes a relatively large change in q to have much effect on the value of W. Thus an error of eight per cent. in determining the heat of dissociation (which is greater than the probable error), would cause only a one per cent. error in W and in a. From the relation previously given, we thus find $a = 0.707a_0 = 0.375 \times 10^{-8}$ cm. When the

electrons are at the ends of their orbits their distance from the center is 0.432×10^{-8} cm. In Bohr's model for the hydrogen molecule the radius of the orbit of the elctrons is 0.953 a_0 or 0.506×10^{-8} cm. In the new model the distance of the nuclei from the center is 0.232×10^{-8} cm. while in Bohr's model this distance is 0.292×10^{-8} cm. The moment of inertia of the molecule about its center is thus 1.78×10^{-41} g. cm.[2] for the new model while Bohr's model gives $2.81 \times^{-41}$ g. cm.[2] From the theory of band spectra which has recently been developed by Lenz, Heurlinger and others it is possible to calculate the moment of inertia of the hydrogen molecule from certain relationships between lines of the secondary spectrum of hydrogen which were found by Fulcher and Croze. Thus Sommerfeld[1] calculates that the moment of inertia of the hydrogen molecule is 1.85×10^{-41}. This value agrees within four per cent. with that calculated from the new model (1.78×10^{-41}) while Bohr's model gives a value 52 per cent. too high.

It is of interest to enquire if there are not other simple models for the hydrogen molecule which are consistent with the known chemical facts regarding the remarkable stability of a pair of electrons in molecules. Sommerfeld has modified Bohr's original theory of atomic structure by considering elliptical as well as circular orbits. A two-quantum orbit of an electron in an atom may have both quanta in the form of angular momentum (circular orbit), or there may be one quantum of angular and one of radical momentum (elliptical orbit). Both quanta can not be in the form of radial momentum, for the ellipse would then degenerate into a straight line which would pass through the nucleus and this would lead to infinite velocities for the electron. This reason for the exclusion of orbits having only radial quanta fails for the case of a molecule in which there is no nucleus at the center. We should therefore consider models for the hydrogen molecule in which the two electrons oscillate in and out along a straight line passing through the center of the molecule, and perpendicular to the line joining the two nuclei. The repulsion of the electrons for each other would prevent them from reaching the center. We assume of course that the two electrons are coupled together by some quantum relationship, in such a way that they are always at equal distances from the center. If the electrons are at their greatest distance from the center they are more strongly attracted by the two nuclei than they are repelled from each other and they therefore fall in towards the center. When they get close to the center the repulsion increases rapidly and finally causes the electrons to rebound to their original positions. When the electrons are far apart there is a net repulsive force between the nuclei, but when the electrons are close together the attractive force on the nuclei predominates. The length of the path traveled by the electrons must be so related to the distance between the nuclei that the time averages of the repulsive and attractive forces acting on the nuclei must be equal.

By a series of approximations, based wholly on the classical mechanics, the following results have been calculated. If we take b. the distance between the center of the molecule and the nuclei as unity, the maximum distance reached by the electrons (from the center) is 3.710, while the minimum distance within which they approach the center is 0.1644. The electrons attain their greatest velocity when they are at a distance of 0.5773 from the center, and if they continued to move with this velocity they would travel a distance 8.989 in the time that it actually takes to move from the position of nearest approach to the point in the orbit furthest from the center. The total energy W of the molecule according to this model is 0.8124 $W_0 a_0/b$ where W_0 and a_0 have the same meanings as before.

In the absence of definite knowledge as to how to apply the quantum theory to this model we may calculate the absolute dimensions from the heat of dissociation. Taking

[1] "Atombau und Spectrallinien," p. 561, 2d edition, soon to be published.

as before $W = 2.270\ W_0$ we find for b, the distance from the nuclei to the center of the molecule, the value 0.190×10^{-8} cm. The moment of inertia is thus 1.20×10^{-41} g. cm.[2] Since this value does not agree at all well with the value 1.85×10^{-41} calculated from the spectrum it is improbable that this model corresponds to the true structure of the hydrogen molecule in its normal state. It may be however that such a model with a different value for b may apply to a disturbed state of the molecule.

According to Bohr's theory in which the paths of electrons are circular, a hydrogen ion consisting of two hydrogen nuclei with one electron, should not be capable of existing, for the value of W for such a structure ($0.88\ W_0$) is less than that for the hydrogen atom and the ion should therefore break up into an electron and a hydrogen atom. There seems to be considerable experimental evidence[2] that the positive H_2 ion is stable and is formed from ordinary molecular hydrogen when an ionizing voltage of about 11 volts is applied.

Since the H_2^+ ion has two nuclei there is no obvious necessity for assuming a circular path for the electron. I have therefore considered a model in which the electron oscillates along a rectilinear path passing through the center of the ion and perpendicular to the line joining the nuclei. By the methods of the classical mechanics it can be shown that if we take b, the distance between the center of the ion and the nuclei, as unity, then the maximum displacement of the electron from the center (*i. e.,* at the end of its path) is 2.214. The velocity of the electron when it passes the center of the ion is such that if it should continue to move with this velocity it would travel a distance 5.148 during the time that it actually takes to move from the center to the point furthest from the center. The total energy W of the ion is $0.6468\ W_0 a_0/b$. As soon as b is known the ionizing potential of hydrogen corresponding to this model can be calculated.

I have tried to apply the quantum theory in two different ways, although without certainty that either way is correct. According to the first method I have assumed that the angular momentum (or the moment of momentum) of the electron about each of the nuclei is $h/2\pi$ when the electron passes through the center. Of course the angular momentum about one of the nuclei decreases as the electron moves further from the center but this is due to the fact that the momentum is imparted to the other nucleus. A consideration of Landé's models for the octet, as well as the model which I previously proposed for the helium atom, suggests that in structures having more than one electron and one nucleus, we are concerned not with the momentum possessed by any electron, but rather with the momentum which is *transferred* from one electron to another or from an electron to a nucleus. On the basis of this assumption, it can be readily calculated that the value of b, the distance of the nuclei from the center, is $0.4250\ a_0$ or 0.225×10^{-8} cm. The energy of the ion is then $1.522\ W_0$. Since this is larger than that for the hydrogen atom, this ion will be stable. The difference between this energy and that for the hydrogen molecule (*i. e.,* $0.748\ W_0$) corresponds to the energy required for ionization. Expressed in volts this is 10.15 volts, which is in fair agreement with the experimental values (11 to 11.5 volts).

In the second method of applying the quantum theory I have used the relation $\int p dq = h$ where I have taken q to be the distance measured from the center along the rectilinear path, and p is the momentum in the direction of this path. As far as I know there is no good reason for choosing this particular coordinate system except that it seems to be the simplest. These assumptions lead to the value $b = 0.5261\ a_0 = 0.279 \times 10^{-8}$ cm. The energy is then $1.229\ W_0$, which again corresponds to a stable hydrogen ion but the ionizing potential is 14.1 volts.

The evidence in favor for these models is far from conclusive but in view of the fact that Bohr's models for the hydrogen molecule and ion can not be correct it seems important

[2] See particularly Franck, Knipping and Krüger, *Deut. Phys. Ges. Verh.,* 21, 728 (1919).

to test out the new models in as many ways as possible. The mathematical calculations upon which these models are based will probably be published in the *Physical Review*.

IRVING LANGMUIR

RESEARCH LABORATORY,
GENERAL ELECTRIC CO.,
SCHENECTADY, N. Y.,
October 13, 1920

SCIENTIFIC EVENTS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

EDWIN S. CARMAN, manufacturer, of Cleveland, Ohio, has been elected president of the American Society of Mechanical Engineers in a mail ballot covering a membership of 13,000 engineers, managers and technologists in every industrial center of the country. Mr. Carman succeeds Major Fred J. Miller, of this city. He will take office after the society's annual convention, which will be held in New York in December.

John L. Harrington, consulting engineer, of Kansas City; Leon P. Alford, editor, of New York, and Robert B. Wolf, president of the R. B. Wolf Company, of New York, were chosen vice-presidents for two years in succession to John A. Stevens, of Lowell, Mass; Henry B. Sargent, of New Haven, Conn, and Fred R. Low, of this city.

Three managers, each for a term of three years, were elected, as follows: Henry M. Norris, of Cincinnati; Carl C. Thomas, of Los Angeles; Louis C. Nordmeyer, of St. Louis. Major William H. Wiley, publisher, of New York, was re-elected treasurer. The secretary will be elected by the society's council in December. Calvin W. Rice has held this office since 1906.

Following a meeting of the society's council, composed of the president, vice-presidents, managers, past presidents, treasurer and secretary, representing engineering effort in many sections of the country, and with a membership of twenty-one, broad plans for promoting professional endeavor and public service, particularly as to industrial relations and rewarding engineering achievement, were announced. The finance committee recommended a budget for the ensuing year of over $500,000.

The meetings and progress committee detailed plans for the annual convention of the society in New York in December and also announced plans for a congress of mechanical engineers to be held in Chicago next spring.

THE AMERICAN ORNITHOLOGISTS' UNION

THE thirty-eighth stated meeting of The American Ornithologists' Union will convene in Washington, D. C., November 9–11.

Headquarters will be at The Harrington, 11th and E Streets, N. W., four blocks from the U. S. National Museum. Owing to the crowded condition of hotels in Washington members intending to be present are urged to make reservations well in advance.

The public meetings will be held in the U. S. National Museum, from 10 A.M. until 4.30 P.M. each day.

The reading of papers will form a prominent feature of the meetings. All classes of members are earnestly requested to contribute, and to notify the secretary before November 1, as to the titles of their communications and the length of time required for their presentation, so that a program for each day may be prepared.

In addition to the usual social features there will be opportunities to visit various places of interest, including the National Zoological Park and the Library of Congress. Arrangements have been made for a special exhibit in the library, showing the development of zoological illustrations as applied to birds and original drawings and photographs of birds by American artists and photographers.

T. S. PALMER,
Secretary

1939 BILTMORE ST., N. W.,
WASHINGTON, D. C.

THE AMERICAN SOCIETY OF NATURALISTS

THE American Society of Naturalists will hold its thirty-eighth annual meeting at Chicago, under the auspices of the University of Chicago, beginning on Thursday, December

30. The program of Thursday morning will be devoted to papers contributed by members and invited guests; this program may be continued on Friday if of sufficient length. It is expected that problems of organic evolution will be the central theme of these papers. On Thursday afternoon will be held a symposium on "General physiology." The Naturalists' dinner will be given Thursday evening, and at its close Dr. Jacques Loeb will deliver the presidential address on the subject "On osmosis."

Headquarters of the society will be at the Congress Hotel, Michigan Boulevard and Congress Street, in conjunction with other biological societies. Rooms without bath for one person may be had for three to five dollars; rooms with bath for one person range from four to nine dollars, and for two persons from seven dollars up. Members desiring accommodations at headquarters are urged to make reservations early in order that there may be no disappointments.

A. Franklin Shull,
Secretary

University of Michigan,
Ann Arbor, Mich.

THE ASSOCIATION OF AMERICAN GEOGRAPHERS AT THE CHICAGO MEETING

The seventeenth annual meeting of the Association of American Geographers under the direction of the President, Professor Herbert E. Gregory, will be held at Chicago, on Thursday and Friday, December 30 and 31, and also Saturday, January 1. Through the courtesy of the department of geography of the University of Chicago, the meetings will be held in Rosenwald Hall, where facilities for use of illustrative materials are provided.

The morning sessions will open at ten o'clock and close at one o'clock; the afternoon sessions will run from two-thirty to five-thirty. On Thursday evening at eight o'clock there will be a round table conference on the policy of the association at the hotel; on Friday evening there will be an informal conference at the hotel on cooperation in geographic research.

By vote of the council there will be a joint meeting with the Ecological Society of America on Friday morning. The speakers from this Association will be Professors Henry C. Cowles and A. G. Ruthven; the speakers from the Ecological Society will be Drs. D. T. MacDougall and V. C. Shelford. The President's address will be given at the opening of the session on Friday afternoon, and will be followed by three invited papers on industrial geography, according to the decision of the council at the spring meeting.

The nominating committee, consisting of R. H. Whitbeck, chairman, R. DeC. Ward and J. W. Goldthwaite, presents the following nominations for officers for 1921.

President—Ellen Churchill Semple.
Vice-presidents—A. J. Henry, Curtis F. Marbut.
Secretary—Richard E. Dodge.
Treasurer—George B. Roorbach.
Councilor—Nevin M. Fenneman.

All interested in geography, or its allied subjects, are cordially invited to attend the meetings of the association.

Richard Elwood Dodge,
Secretary

Storrs, Connecticut,
October 20, 1920

THE DEPARTMENT OF CHEMISTRY OF THE OHIO STATE UNIVERSITY

The department of chemistry of The Ohio State University held a chemical symposium on Saturday, October 16, as one of its contributions to the celebration on the occasion of the semi-centennial of the founding of the university from October 13 to 16. The following program was presented by the alumni of the department:

"A brief history of the department of chemistry," by William McPherson, head department of chemistry, The Ohio State University.

"The organization of a chemistry department," by Winfred F. Coover, professor of chemistry, Iowa State College.

"A chemical attack upon the unsolved problem of human diabetes," by Dr. Edgar J. Witzemann, research chemist for the Otho Sprague Memorial Institute, Rush Medical College, University of Chicago.

"Problems in the petroleum industry," by Colonel George A. Burrell (formerly head of Research Division, Chemical Warfare Service, U. S. Army), now president, The Gasoline Recovery Co., New York City.

"The composition of automobile exhaust gas in reference to the ventilation of vehicular tunnels," by Major Arno C. Fieldner, research chemist, Bureau of Mines, Pittsburgh, Pa.

On Friday evening preceding the symposium, a banquet of one hundred and thirty alumni and former students of the department was held at the Hartman Hotel. Among the speakers on this occasion were: Mr. Frederick W. Sperr, Jr., The Koppers Co.; Dr. Benjamin T. Brooks, The Mathieson Alkali Works; Mr. Frank O. Clements, General Motors Research Corporation; Professor Charles W. Foulk, department of chemistry, The Ohio State University; Mr. Cole Coolidge, department of chemistry, Ohio State University; Mrs. Carl Gay, and Mrs. George W. Stratton.

DEDICATION OF THE EDWARD ORTON MEMORIAL LIBRARY

THE Edward Orton Memorial Library was dedicated on Saturday, October 16, the exercises forming a part of the semi-centennial celebration of the Ohio State University. Edward Orton was the first president of that institution, its professor of geology until 1899, and state geologist of Ohio from 1882 until his death in 1899. The library, named in his honor, is a gift of his son, Colonel Edward Orton, Jr. It is located in Orton Hall and was opened for use late in 1917. The absence of Colonel Orton because of his duties in the war department prevented a dedication at that time.

Dr. I. C. White, president of the Geological Society of America, spoke on the contributions of Dr. Orton to geology; Colonel Orton spoke on the Edward Orton Memorial Library and announced the presentation of a set of the *Alpine Journal* and of $500 and stated that he would give a like amount from time to time. A reception followed and later the guests were entertained at luncheon.

The books of this library consist chiefly of the university collection, the geological survey collection and the Prosser library. The rooms are well lighted and commodious and the furnishings and equipment are unsurpassed by those of any similar library in the country.

SCIENTIFIC NOTES AND NEWS

NOBEL prizes have been awarded to Dr. Jules Bordet, professor of bacteriology at Brussels, and Dr. August Krogh, professor of oceanography at Copenhagen.

PROFESSOR F. FRANCIS, professor of chemistry in the University of Bristol, has been elected a corresponding member of the Belgian Royal Academy of Medicine.

DR. P. V. WELLS is returning to the Bureau of Standards after completing his investigations on the stratification of thin soap films, which he has been carrying forward at the laboratory of Professor Perrin in Paris.

GEORGE C. WHIPPLE, Gordon McKay professor of sanitary engineering, has returned to Cambridge after an absence of eight months, during which he has been chief of the Division of Sanitation of the League of Red Cross Societies, with headquarters at Geneva, Switzerland. His term of service ended on October 1, when he became consulting sanitary engineer. During the month of May, Professor Whipple and others visited Roumania to make an inspection of the methods for combating typhus and cholera.

NEIL M. JUDD, curator of American archeology, United States National Museum, has returned to Washington after having spent the last five months in Utah, Arizona and New Mexico, engaged in archeological investigations for the Bureau of American Ethnology and the National Geographical Society.

ERNEST M. GRESS, Ph.D. (Pittsburgh, 1920), has been appointed botanist in the Pennsylvania Bureau of Plant Industry, Harrisburg. In connection with his other duties Dr. Gress will undertake the upbuilding of an extensive herbarium at Harrisburg.

A. C. BOYLE, JR., mining engineer, and professor at the University of Wyoming, has re-

signed from the university to accept the position of geologist with the Union Pacific R. R. Co., with headquarters in Omaha, Nebraska.

F. W. Lommen, formerly research chemist in the Sprague Memorial Institute, Chicago, is now research chemist with the National Carbon Company at Cleveland.

The *Proceedings* of the Washington Academy of Sciences records resignations from the scientific service of the government as follows: Mr. A. H. Taylor, of the photometer section of the Bureau of Standards, has accepted a position at the Nela Research Laboratory of the General Electric Company. Mr. F. H. Tucker, associate chemist at the Bureau of Standards, has taken up research work at the New York laboratories of the Chile Exploration Company. Mr. Reeves W. Hart has resigned from the Leather Section of the Bureau of Standards, to become research chemist at the Benicia tannery, California. Mayo D Hersey, chief of the Aeronautic Instrument Section of the Bureau of Standards, has taken the position of associate professor of properties of matter, in the department of physics of the Massachusetts Institute of Technology. He is succeeded at the bureau by Dr. F. L. Hunt. Dr. Harrison E. Patten has resigned from the Bureau of Chemistry, U. S. Department of Agriculture, to accept a position as chief chemist with the Provident Chemical Company of St. Louis, Missouri. Kenneth P. Monroe, of the color laboratory of the Bureau of Chemistry, has accepted a position at the Jackson Laboratory of E. I. du Pont de Nemours and Company, Wilmington, Delaware.

At the meeting of the American Philosophical Society on November 5 the program consists of an illustrated paper by the president of the society, Professor William B. Scott, on "The Astrapotheria, a remarkable group of prehistoric South American animals."

A general discussion on "The physics and chemistry of colloids, and their bearing on industrial questions," was arranged jointly by the Faraday Society and the Physical Society of London, on October 25. The discussion was presided over by Professor Sir W. H. Bragg, and was introduced by Professor Svedberg, of the University of Upsala.

Professor Leotta, of Rome, Dumas, of Paris, and S. Rossi, of Montevideo, have recently delivered scientific lectures in Vienna.

Arthur Searle, Phillips professor emeritus of astronomy at Harvard University, died at his home in Cambridge on October 23. Professor Searle, who was born in England in 1847 and graduated from Harvard in 1856, became assistant in the Harvard College Observatory in 1869, retiring from active service in 1912.

Professor Yves Delage, professor of zoology at the Sorbonne, Paris, died October 8, at sixty-six years of age.

Sven Leonhard Törnquist, Professor of geology at Lund, died on September 6 at the age of eighty years.

Dr. F. Hofmann, professor of hygiene at the University of Leipzig, has died at the age of seventy-seven years.

General William C. Gorgas, former surgeon general of the Army, left an estate valued at $20,500, according to the petition of the probate of his will filed by his widow, Mrs. Marie D. Gorgas. The estate includes a house at Chevy Chase, Md., and life insurance.

The dean of the medical faculty of the University of Paris has been authorized in the name of the university to accept from Mme. Auguste Klumpke, widow of Professor Dejerine, the gift of the pathologico-anatomic collection of Dr. Dejerine, as well as a fund yielding 100,000 francs annually. A museum of neurology, including a laboratory, will be established which will bear the name of the J. Dejerine Foundation

A Ramsay Memorial Fellowship of the value of £300 a year for three years has been founded by subscriptions received from the Swiss Government and from Swiss donors, through the good offices of Professor Ph. A. Guye, of Geneva. The first Fellow to be elected is M. Etienne Roux, of Vich (Vaud),

Switzerland, who has decided to work in the laboratories of Professor W. H. Perkin, at Oxford.

THE one hundred and fifth regular meeting of the American Physical Society will be held in Cleveland, at the physical laboratory of Case School of Applied Science on Friday and Saturday, November 26 and 27, 1920. Other meetings for the current season are as follows: December 28–31, Chicago; annual meeting, February 25–26, New York; April 22–23, Washington; time not determined, Pacific Coast section.

THE Society of Biology of Buenos Aires has become a branch of the Society of Biology of Paris.

UNIVERSITY AND EDUCATIONAL NEWS

THE University of Virginia, founded by Thomas Jefferson, is preparing to celebrate its centennial anniversary next June, when it is expected that the alumni and friends will present an endowment fund of three million dollars.

DR. FRANK BILLINGS, who is professor of medicine in the University of Chicago, has given his medical library valued at $25,000 to the university. It will form the nucleus of the clinical library of the Medical School and will be eventually housed in the Albert Merritt Billings Hospital.

THE mayor of Frankfurt has announced that an endowment of 1,500,000 marks has been made to the Frankfurt University by James Speyer, the New York banker, in memory of his deceased sister, Mrs. Eduard Beit Von Speyer.

DR. WALTER DILL SCOTT, professor of phychology in Northwestern University and president of the Scott Company, who during the war was director of the committee on personnel and colonel, U. S A., has been elected president of Northwestern University.

MR. R. T. HASLAM, of the National Carbon Company, Cleveland, Ohio, has become director of the School of Chemical Engineering Practice of the Massachusetts Institute of Technology.

SAMUEL L. BOOTHROYD has been appointed professor of astronomy and geodesy at Cornell University, to succeed Professor O. M. Leland. Professor Boothroyd's appointment takes effect in September, 1921, in order that he may spend the coming year at the Lick Observatory, Mount Hamilton, California.

WILLIAM BERTOLLET PLANK, superintendent of the United States Bureau of Mines Station, Birmingham, Alabama, has been appointed to the George B. Markle professorship of mining engineering at Lafayette College. Other new appointments in the Engineering School the current year are Morland King, of Union College, to be associate professor of electrical engineering, William S. Lohr, of Lancaster, to be associate professor of civil engineering, and Luther F. Witmer, of the United States Bureau of Standards, to be associate professor of metallurgy.

AT the University of Iowa the following promotions to full professorships have been made: James Newton Pearce, chemistry; Lee Paul Sieg, physics; Ewen Murchison McEwen, anatomy, and John Hoffman Dunlap, hydraulics and sanitary engineering.

AT the State University of Iowa, Dr. Dayton Stoner has been promoted from associate in zoology to assistant professor of zoology.

ON returning to New York on September 29 from a collecting trip in northern Norway, H. P. K. Agersborg, instructor in anatomy, Long Island College Hospital, was appointed assistant professor of zoology, at the University of Wyoming.

DR. ARDREY W. DOWNS has been appointed to the chair of physiology in the University of Alberta. Dr. Downs was formerly assistant professor of physiology at McGill University.

DR. GRIFFITH TAYLOR, physiographer in the Weather Service, Melbourne, has been appointed to a specially created position of asso-

ciate professor of geography in the University of Sydney.

DISCUSSION AND CORRESPONDENCE

VISIBLE SOUND WAVES

The following notes, written by Lieutenant Thomas T. Mackie, 123d Field Artillery, A. E. F., describe a phenomenon which must have been observed rarely, if ever before, and it seems to be very much worth while to put the circumstances on record.

On one or two occasions within recent years the occurrence of sound waves visible to the naked eye under peculiar atmospheric conditions has, I believe, been reported; yet the event is so unusual that I have been persuaded to describe a similar one which I witnessed at the front on the opening day of the Meuse-Argonne offensive.

During the days immediately preceding the attack my regiment moved into position in a wooded area opposite Montfaucon, characterized by the roughness of the terrain, a jumble of high hills cut up by narrow and deep valleys. The battery to which I belonged was sent into position at the head of one of these valleys, enclosed by very steep slopes, and having roughly the shape of a V with the open end to the south. Some four or five hundred yards to our rear and approximately on a line with the extremities of the arms of the V was a battery of six-inch rifles.

For several days the weather had been more or less rainy and wet, and the morning of September 26 found us covered by a very heavy bank of fog which entirely excluded the sun. Soon after the attack opened, I had occasion to go to the top of one of the hills which flanked our position, and at a certain definite level above the battery a very considerable disturbance in the fog was noticeable after each discharge of the heavy rifles behind me. The visibility was such that the flash of the discharge could not be seen, but each time before the report reached us a band of greater density was clearly visible in the fog, moving with great rapidity up the valley toward us in the form of an arc. Its arrival was simultaneous with that of the sound of the discharge. This arc of greater fog density was perhaps six feet from its anterior to its posterior edge, and of about the same depth. It followed closely an altitude of some sixty or seventy feet above the floor of the valley and was clearly visible from both above and below that plane, but no similar phenomena were visible in any other plane.

The recent researches of Professor D. C. Miller, and others have shown that the muzzle wave from a large gun carries in its front a narrow region of compression immediately followed by a relatively wide region of expansion. From the above account, it would appear that the air was saturated with water vapor at a particular level, and that the expansion in the wave produced a visible increase in the fog density, the effect disappearing immediately again, owing to the subsequent re-evaporation when the air regained its normal pressure and temperature. The conditions of the terrain were very favorable to the concentration of a great amount of energy into the wave-front, and this was probably assisted by a sound-mirage effect. The upper layers of air being warmer than the lower the sound wave-fronts would be so bent as to tend to keep the energy near the earth's surface. The "experiment" was thus being conducted under such circumstances and on such a scale as can not readily be reproduced in the laboratory, and would rarely occur anywhere.

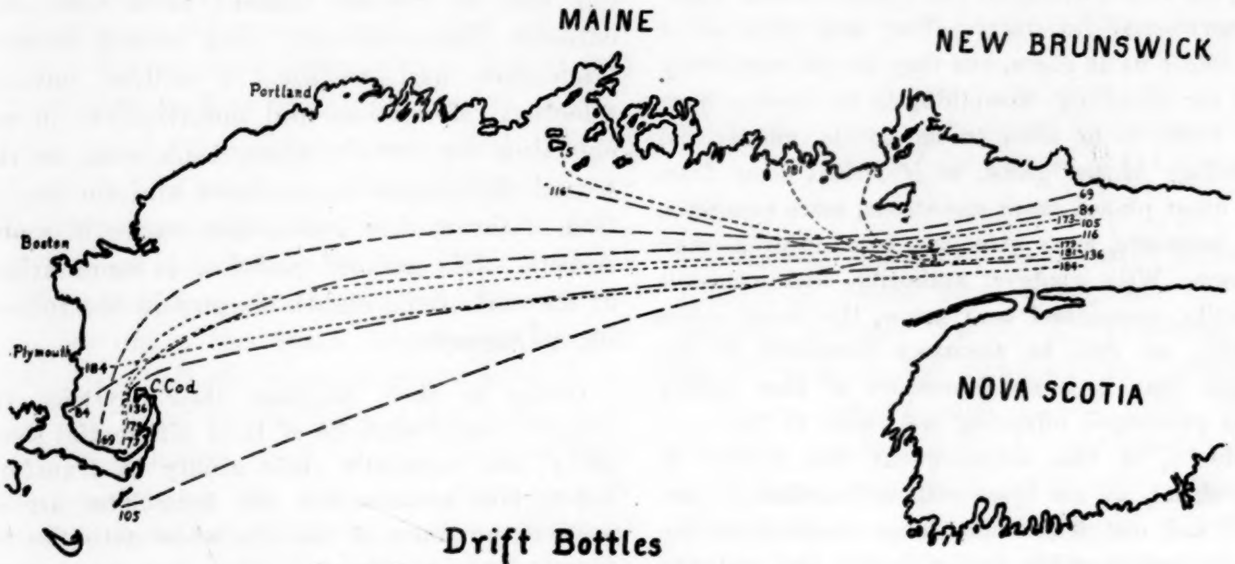
Frederick A. Saunders
Jefferson Physical Laboratory,
Harvard University,
October, 1920

DRIFT BOTTLES AS INDICATING A SUPERFICIAL CIRCULATION IN THE GULF OF MAINE

In his "Explorations in the Gulf of Maine" H. B. Bigelow[1] has found evidence of a circulation of the water in the gulf. Since this evidence depends chiefly on the contours of the osohalines and the distribution of plankton, the direction and rate of movement of the drift bottles to be described, obtained incidentally in another investigation may be of importance in adding to this evidence. During the summer of 1919 as part of the hydrographic work in the Bay of Fundy by the Biological Board of Canada, 330 drift bottles were set out in the bay. Sixteen of these bottles have been picked up on the shores of the Gulf of Maine. The

[1] *Bull. Mus. Comp. Zool.*, Vol. 58, p. 29; Vol. 59, p. 149; Vol. 61, p. 163

distribution of the bottles which left the Bay of Fundy from two of these sets is shown in the figure, where the interrupted lines merely join the points of setting out and finding of the bottles, and are not intended necessarily to indicate the course which the bottle may have taken. The bottles were set out between June 18 and September 26 in sets spaced in lines across the bay at various distances from its entrance. Each bottle contained a Canadian postcard on which was printed besides the address of the Biological Station the offer of a reward to the finder who wrote the time and place of finding and posted the card. The bottles were of two kinds; two-ounce bottles and eight-ounce bottles; to the latter a galvanized iron drag was attached to hang at a depth of three fathoms, the object of the drag being to minimize the direct effect of the wind. Fifty-five of these latter bottles with drags were set out and six have been found and reported from outside the Bay of Fundy, to date (August 6, 1920). Three of these were picked up on the Cape Cod peninsula, the rest on the coast of Maine. Of the two hundred and seventy-five bottles without drags, ten have been reported from outside the bay. Eight of these ten were picked up on the Cape Cod peninsula, the other two on the coast of Maine. (See figure which shows only the bottles of the first two sets.)



Drift Bottles
Set A. Nos. 3, 5, with drags put out June 18
Set D. Nos. 69-136, without drags put out Aug. 21
Set E. Nos. 173-184, with drags put out Aug. 21

FIG. 1.

The times when the bottles were found are significant since they establish a minimum rate for the drift. Seven out of the eleven bottles which went to Cape Cod were found between 70 and 80 days after being put out, the shortest time being 73 days. The distance in a straight line from the Bay of Fundy is about 300 nautical miles. The rate of the drift was therefore about four nautical miles per day.

The drift of these bottles, set out at various times during the summer, indicates a surface movement of the water from the Bay of Fundy through the northwestern part of the Gulf of Maine and striking Cape Cod, the rate of this drift being about four nautical miles per day.

JAMES W. MAVOR
UNION COLLEGE

SCIENTIFIC BOOKS

La Vie Psychique des Insectes. Bibliothèque de Philosophie Scientifique. By C. L. BOUVIER. Paris, Ernest Flammarion, 1918. 299 pp.

In this interesting little volume Bouvier endeavors to present an up-to-date sketch of insect behavior. In the introduction he quotes the following remarkable passage from Maeterlinck's paper on Fabre and his work:[1]

The insect does not belong to our world. Other animals and even the plants, despite their mute lives and the great secrets they enfold, seem not to be such total strangers, for we still feel in them, notwithstanding all their peculiarities, a certain terrestrial fraternity. They may surprise or even amaze us at times, but they do not completely upset our thoughts. Something in the insects, however, seems to be alien to the habits, morals and psychology of our globe, as if it had come from some other planet, more monstrous, more energetic, more insensate, more atrocious, more infernal than our own. With whatever authority, with whatever fecundity, unequalled here below, the insect seizes on life, we fail to accustom ourselves to the thought that it is an expression of that nature whose privileged offspring we claim to be. . . . No doubt, in this astonishment and failure to comprehend, we are beset with an indefinable, profound and instinctive uneasiness, inspired by beings so incomparably better armed and endowed than ourselves, concentrations of energy and activity in which we divine our most mysterious foes, the rivals of our last hours and perhaps our successors. . . .

And Bouvier adds:

We have the feeling that the psychic evolution of these animals must be no less original than their structure and that they never differ so greatly from us as when they seem to resemble us most closely.

Bouvier's discussion of the psychic life of insects is divided into two parts, a "methodical" part, comprising Chapters I. to IX. and a "special" part, comprising the five concluding chapters. The methodical part treats of the tropisms, vital rhythms, differential sensibility, organic, specific and individual (associative) memory, the learning process, the modifications of habits, the evolution of instincts and in the ninth chapter of the comparative or historical method as illustrated by a single Hymenopterous family, the Psammocharidæ (Pompilidæ). Loeb and Bohn are at first rather rigidly followed, and the author is not very favorable to the position of Jennings. He attributes the "trial and error" activities to differential sensibility and even tries to use this as a partial explanation of "death feigning." But later his treatment of the problems of insect behavior broadens out and he reveals himself as a sane and catholic Neolamarckian, with strong eclectic tendencies and willing to utilize natural selection, Mendelism and mutationism in accounting for certain phenomena such as the sexual differences in instincts and the evolution of the worker and soldier castes in social insects. His general position is summarized at the end of the eighth chapter in the following paragraphs:

Owing to their tropisms, their rhythms, the adaptive manifestations of their differential sensibility, but especially their ability to transform habits into automatisms, the Articulates are essentially creatures of instinct, whose activities are largely made up of automatisms, but automatisms dominated by cerebral control ("puissance cérébrale"). They can not be regarded as simple "reflex machines," because they can adapt themselves to circumstances, acquire new habits, learn to remember, and manifest discernment. They might be regarded as somnambules, whose minds awake and give evidence of intelligence when the need is felt, and this takes us a long way beyond the mechanism of which Bethe has made himself the protagonist.

The activity of insects is characterized by two essential peculiarities: first, the presence of multiple, more or less perfectly adapted appendages, and second, the power very quickly to transform acts originally intelligent into automatic acts. This latter character is without doubt a consequence of the former, for the appendages are instruments both structurally and functionally almost congealed (figés). At any rate, there can be no doubt that this is the principal factor in the evolution of the Articulates. Owing to this peculiarity, in fact, the automatic activity of the animal can go on enriching itself with new elements borrowed from intelligence and thus adapted to new necessities. A substratum of activity is thus produced and develops, permitting intelli-

[1] *Ann. Polit. Lit.*, 2 Avril, 1911.

gence, as Bergson says, to mount on the wings of instinct. It does not soar far, nor very high, because its efforts very soon congeal in automatic form, but with each attempt the instinctive substratum is augmented to give the animal a vaster field of activity. Thus we reach the higher Articulates in which the most complex automatic activities, fringed with intelligence, become concatenated and purposive as if they had been regulated by reason. Hence we repeat here what we said at the beginning of the present work: The Articulates never differ so greatly from us as when they seem to resemble us most closely.

Chapter IX. on the behavior of the Pompilids, drawn very largely from the valuable researches of Pérez and his pupil Ferton, is admirably written and can be recommended to those who are inclined to underestimate the value of ethological and historical methods in comparative psychology. An even more interesting chapter could, however, be compiled from the literature on these solitary wasps. On page 161 Bouvier tells us that "it is unfortunate that no biologist up to the present time has been able to witness the oviposition of *Ceropales*," thus overlooking completely the very interesting observations of Adlerz[2] on the surreptitious oviposition of this parasite in the lung-books of the spiders that have been captured by the host Pompilid. The extraordinary habits of one of the American Pompilids, described by Needham and Lloyd in their "Life of Inland Waters," 1916, also deserve mention in such a chapter as the one under consideration. According to these authors,

> There is a black wasp, *Priocnemis flavicornis*, occasionally seen on Fall Creek at the Cornell Biological Field Station, that combines flying with water transportation. Beavers swim with boughs for their dam, and water striders run across the surface carrying their booty, but here is a wasp that flies above the surface towing a load too heavy to be carried. The freight is the body of a huge black spider several times as large as the body of the wasp. It is captured by the wasp in a waterside hunting expedition, paralyzed by a sting adroitly placed, and is to be used for provisioning her nest. It could scarcely be dragged across the ground, clothed as that is with the dense vegetation of the waterside; but the placid stream is an open highway. Out on to the surface the wasp drags the huge limp black carcass of the spider and, mounting into the air with her engines going and her wings steadily buzzing, she sails across the water, trailing the spider and leaving a wake that is a miniature of that of a passing steamer. She sails a direct and unerring course to the vicinity of her burrow in the bank and brings her cargo ashore at some nearby landing. She hauls it up on the bank and then runs to her hole to see that all is ready. Then she drags the spider up the bank and into her burrow, having saved much time and energy by making use of the open waterway.

Additional peculiarities of habit among the Pompilids have been described by other authors, notably by F. X. Williams in a recent work on the wasps of the Philippines.[3]

In the second part of the work Bouvier discusses certain selected phenomena which have been long and intensively studied by entomologists, the relations of insects to flowers, the homing of bees, ants and other insects, parthenogenesis and the determination of sex among the Hymenoptera and social life among the Articulates. When we consider that the researches on all these subjects have resulted in vast accumulations of observations, often hidden away in inaccessible journals and monographs, and a most bewildering diversity of interpretations, the author deserves high praise for his brief, concise and orderly presentation. Inadequacy of treatment was unavoidable in many cases, as, *e. g.*, the omission of any consideration of the important experimental contributions of Brun (1914) to the subject of the orientation and homing of ants and other animals. Any adequate treatment of even a portion of insect ethology at the present time would, of course, require several volumes and would transcend the powers of any entomologist. Most readers will be delighted with Bouvier's book as it stands, with its lucid diction, its lack of dogmatic assertion, its kindly and

[2] Bik. K. Svensk. Vet. Akad. Hand., 1902.

[3] Bull. No. 14, Exper. Station Hawaiian Sug. Plant. Assoc., 1919.

stimulating tone and its frank acknowledgment of our ignorance in regard to many matters of fundamental importance. So valuable a work should have been printed on much better paper, but the exigencies of the war probably made this impossible. One could have wished also that the author had provided the volume with an index and had seen fit to give careful citations of the many interesting works to which he refers.

W. M. WHEELER

SPECIAL ARTICLES

ON THE PROTEIN CONTENT OF WHEAT

WHEATS of the Pacific coast states are conspicuously low in protein, so much so that western millers are obliged to ship in large quantities of high protein wheat to mix with their domestic wheats in order to manufacture flour of good baking qualities. The cause of the low protein content of western wheats has been the object of considerable investigation on the part of interested agronomists and plant physiologists for the last two decades. Results obtained from these investigations have led to a rather common belief, that the cause of the low protein content of Pacific coast wheat is primarily attributable to peculiar influences of climate.

In an investigation by the writer on the effect of applications of certain forms of soluble nitrogen to plants at different growth phases, results obtained with wheat, one of the plants studied, throw new light upon this protein question. In this paper, only that part of the plan and the results that pertain to the subject under discussion, need be given. These are essentially as follows:

Glazed stone jars were filled with a soil very low in nitrogen. This soil, as taken from the field, had a very low crop-producing power when cereals were planted, but upon receiving a moderate application of soluble nitrogen salt would yield large crops. This soil was planted to a pure strain of White Australian Wheat. Two hundred and fifty milligrams of nitrogen per jar, that is, at the rate of 100 pounds of nitrogen per acre, were added in single applications to different jars, at dfferent times during the growng period of the plants. The nitrogen was added in two forms, $NaNO_3$ and $(NH_4)_2SO_4$, respectively, for two different series that were tested. Every application was made in triplicate. The first application of nitrogen to the first set of triplicates of each of the two series was made at the time of planting, the second was made to other jars 17 days after planting and so on at intervals until the last sets in each of the $NaNO_3$ and $(NH_4)_2SO_4$ series received their nitrogen application 110 days after planting. Every application of nitrogen made to the several sets in the series was, therefore, made at different ages of the plants and obviously represents more or less different growth phases of the plants. The tabulated data for a $NaNO_3$ series will serve as an example of the plan of the investigation and gives the results obtained.

EFFECT OF $NaNO_3$ APPLICATIONS ON THE PROTEIN CONTENT OF SPRING WHEAT APPLIED AT DIFFERENT GROWTH PHASES OF THE PLANTS

Results Average of Triplicate Jars

Date of Planting	Date of Nitrogen Application	Days After Planting When Nitrogen was Applied	Yield of Grain Grams	Commercial Grade	Per Cent. Crude Protein
11/14/19.	11/14/19		9.4	2 Soft white	8.6
11/14/19.	12/1/19	17	10.6	2 " "	9.3
11/14/19.	12/16/19	33	21.0	1 " "	10.4
11/14/19.	1/1/20	48	19.9	2 Hard	11.8
11/14/19.	1/24/20	72	21.9	1 "	13.2
11/14/19.	3/2/20	110	13.1	1 "	15.2

It will be noted that the data show a decided increase (about 77 percent.) in the protein content of wheat obtained from the plants that received nitrogen when they were 110 days old over those that were treated with nitrate at the time of planting. The protein content of the wheat obtained from these two different treatments are respectively 15.2 per cent., and 8.6 per cent. The data show that for each of the different applications of nitrate made after the time of planting, there was a corresponding increase in the protein content of wheat. As these increases in the

protein content of wheat correspond with the length of the period of the different deferred applications of nitrate made after planting, this would indicate a significant relation between the state of development of the plant and when nitrate can be most effectively utilized by the plant in the production of high protein wheat. This emphasizes that the physiological status of the plant, as indicated in its different growth phases, is a factor of great importance in the utilization of plant food available to it.

Not only was the protein content of the wheat increased by all of the deferred applications of nitrogen, but the yield of produce, excepting that obtained by the latest application, was much larger from the plants that received nitrogen for the period of 33 to 72 days after planting than those that received nitrogen during the early growing period. The best quality wheat as determined by commercial grading was secured from the plants that received nitrogen 72 and 110 days after planting. This means that the high protein wheat berry was likewise plump and well filled.

A much fuller account of the investigation with ample analytical data and a critical review of other investigations relating to the subject will shortly appear. It is felt that the results obtained in this investigation do show that the low protein content of Pacific states wheats is not due primarily to the climate as such, but so far as the investigation with this one soil is concerned, is due to insufficiency of available nitrogen at certain growth periods of the plants. That climate is not without effect upon the availability of the plant food in the soil is obvious, but the emphasis to be laid on the climatic complex is that it affects the nutrition of the plant. This can be both in the kind and quantity of each of the different nutrients that may be available to it. That this availability is an important factor in affecting the composition of plant products is shown by the results of this investigation.

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THE VITAMINE REQUIREMENTS OF THE RAT ON DIETS RICH IN PROTEIN, CARBOHYDRATE, AND FAT RESPECTIVELY[1]

IN 1913, one of us (C.F.) showed that the onset of the symptoms of beriberi in pigeons could be hastened by increasing the amount of polished rice fed. This led to the conclusion that the anti-beriberi vitamine—vitamine B—plays an important rôle in carbohydrate metabolism. This observation was confirmed shortly afterwards by Braddon and Cooper and others, although Eijkman and Vedder have denied the validity of this finding.

In a second series of experiments, in which the diets varied as shown in Table I., it will be noticed that beriberi developed in the following order: starch, sugar, casein, and fat.

TABLE I

Diet	Starch, Per Cent.	Sugar, Per Cent.	Casein, Per Cent.	Fat, Per Cent.	Salts, Per Cent.	Onset of Beriberi, Days
Starch...	60	12	12	12	4	24
Sugar....	12	60	12	12	4	28
Casein...	12	12	60	12	4	30
Fat......	12	12	12	60	4	40

In order to check up the results obtained with pigeons in another class of animals, and also with the idea of attempting to throw some light on the prevailing view as to the importance of proteins of high biological value on the etiology of pellagra and war edema, analogous experiments have been carried out on rats. The composition of the diets and the results obtained are shown in Tables II. and III.

TABLE II

Diet[2]	Meat, Gm.	Sugar, Gm.	Starch, Gm.	Lard, Gm.	Salts, Gm.	Autolyzed Yeast, Cc.	Orange, Cc.	Agar, Gm.	Cod-liver Oil, Cc.
Meat	49	12	12	12	3	4	3	3	5
Sugar	12	49	12	12	3	4	3	3	5
Starch	12	12	49	12	3	4	3	3	5
Lard.............	12	12	12	49	3	4	3	3	5

[1] From the Research Laboratory of H. A. Metz.

[2] The meat, sugar, starch, and lard were tested and found to be free from Vitamine B.

TABLE III

Diet	Weight—First 25 Days		Weight—Following 55 Days		Total Weight Increase, Per Cent.[3]
	Increase, Per Cent.	Decrease, Per Cent.	Increase, Per Cent.	Decrease, Per Cent.	
Meat	43	–	86	–	129
Sugar	15	–	55	–	70
Sugar and vitamine[4]	15	–	145	–	160
Starch	6	–	62	–	68
Starch and vitamine[4]	6	–	165	–	171
Lard	–	9	—	8	−17
Lard and vitamine[4]	–	9	34	–	25

The rats on the protein diet did not require the addition of extra vitamine (autolyzed yeast) at all. This may be regarded as the "sparing action of protein on the vitamine requirement." On the other hand, the rats on the fat diet took the extra vitamine with great avidity, but showed only a small advantage over the controls. The replacement of some of the fat by butter was without any significance, no improvement being noted.

On the starch diet, the rats actually needed extra vitamine (about 2 c.c. per day) in order to resume growth. This was likewise true of the rats on the sugar diet except that they appeared not to require as much vitamine for growth as those on the starch diet. On these diets we occasionally observed sudden large increases and losses in weight, suggestive of edema, though no external evidence was seen. As regards the general appearance of the animals, those on the protein diet and those getting extra vitamine looked very healthy, while the others appeared to be in poor shape with the usual evidences of improper nutrition. The rats on the high fat diet, without extra vitamine, presented the poorest appearance.

Out of thirty rats, only one developed keratomalacia, and this rat was getting five per cent. cod-liver oil. The eye condition cleared up on giving autolyzed yeast (about 2 c.c. per day).

The findings reported here show conclusively that although the qualitative food requirements of a well balanced diet have been pretty well established, this can not be said of the quantitative relationship between the dietary constituents necessary for proper nutrition. It is quite conceivable that under the abnormal conditions existing durng the war period and after, the usual ratio between the protein, carbohydrate, and vitamine constituents have been so changed as to present conditions analogous to those described by us in rats.

Theoretically at least, the above conditions could be corrected in either of two ways—(*a*) by increasing the protein and decreasing the carbohydrate intake, or (*b*) by supplying extra vitamine. The curative experiments of edema in rats reported by Miss Kohmann, and also the condition described as pellagra in a monkey, by Miss Chick, may be viewed in the above light. In view of the complications presented by the "sparing action of animal protein on the vitamine requirements," it may be just as well for the present to leave the question open, as to whether or not pellagra and war edema are avitaminoses. Of all the theories regarding pellagra, that expressed by Goldberger in which he states the facts and leaves the matter open for further investigation, appears to us to be the most satisfactory.

Our complete results will be published in detail later on.

CASIMIR FUNK,
HARRY E. DUBIN

[3] In this instance, the figure represents the increase after 60 days, and is practically the same after 80 days, since most of the animals had already attained full size.

[4] Vitamine given during last 55 days.

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